



Solid-to-Liquid Ratio (SLR) Research on Mount Washington

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Solid-to-Liquid Ratio (SLR) Research

What is a SLR?

Ratio between solid accumulation and its liquid equivalent

Calculated by measuring the amount of solid accumulation (in inches) and then melting it to measure the corresponding amount of water (in inches)

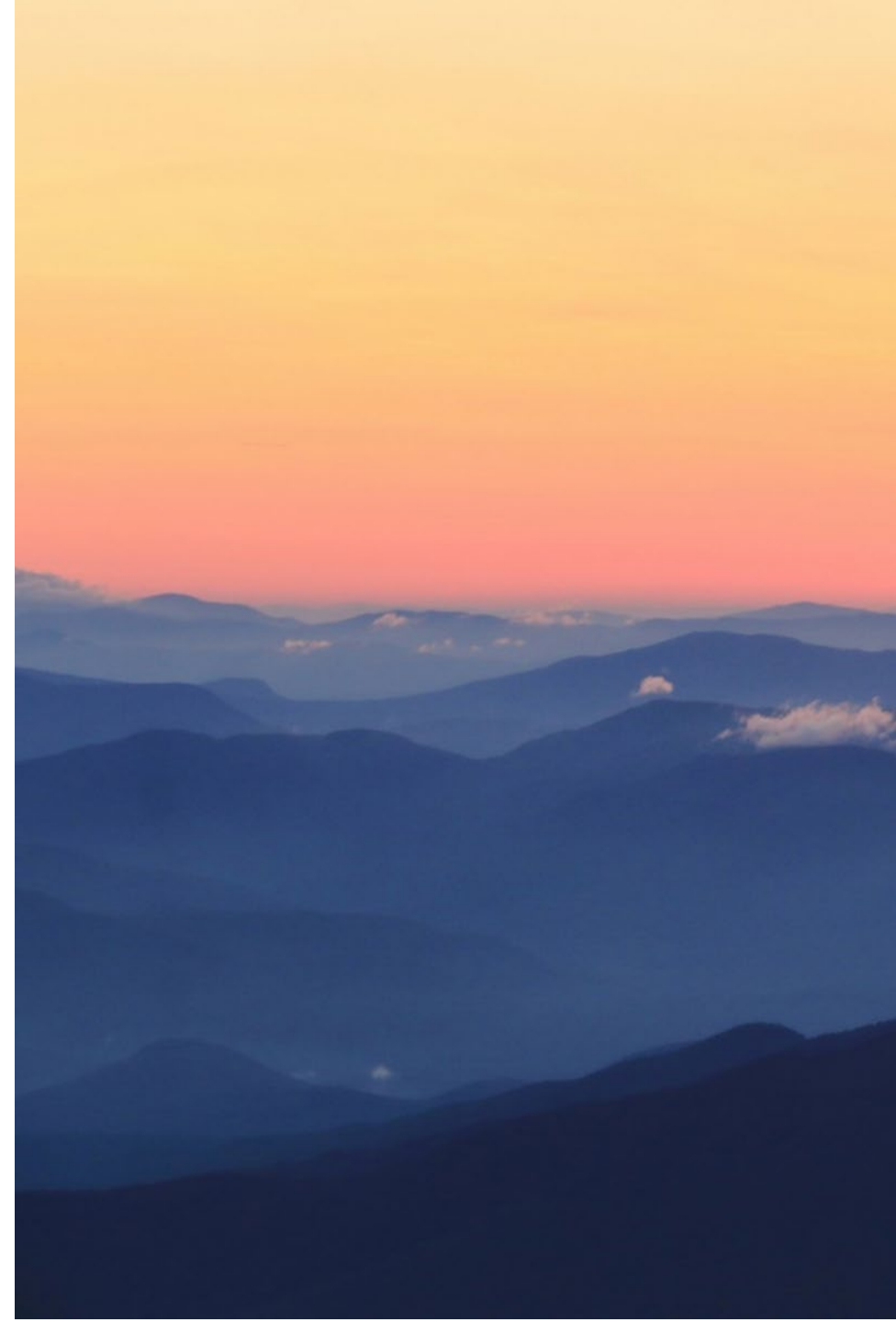
$$SLR = \frac{\text{Solid Accumulation}}{\text{Liquid Equivalent}}$$

Solid-to-Liquid Ratio (SLR) Research

$$SLR = \frac{\textit{Solid Accumulation}}{\textit{Liquid Equivalent}}$$

Why?

- Knowledge of SLR and how it varies by location, and in relation to different weather variables is important for accurately forecasting total accumulations, societal impacts, and avalanche conditions
- Mount Washington's extensive dataset allows us to determine how it may be changing over time if expanded from just 2023 to a full climatology (30 years), or even longer
- Understand relationships between SLR and temperature, winds, and seasonality



Datasets Utilized

While Mount Washington historical record contains over 90 years of hourly weather observations, this analysis used data from only 2023

B-16 data:

Hourly observations of wind speed, wind direction, temperature, and present weather

B-15 data:

6-hourly observations of maximum and minimum temperature, and depths of liquid and solid precipitation





Data from the Mount Washington Observatory

Filtering Data

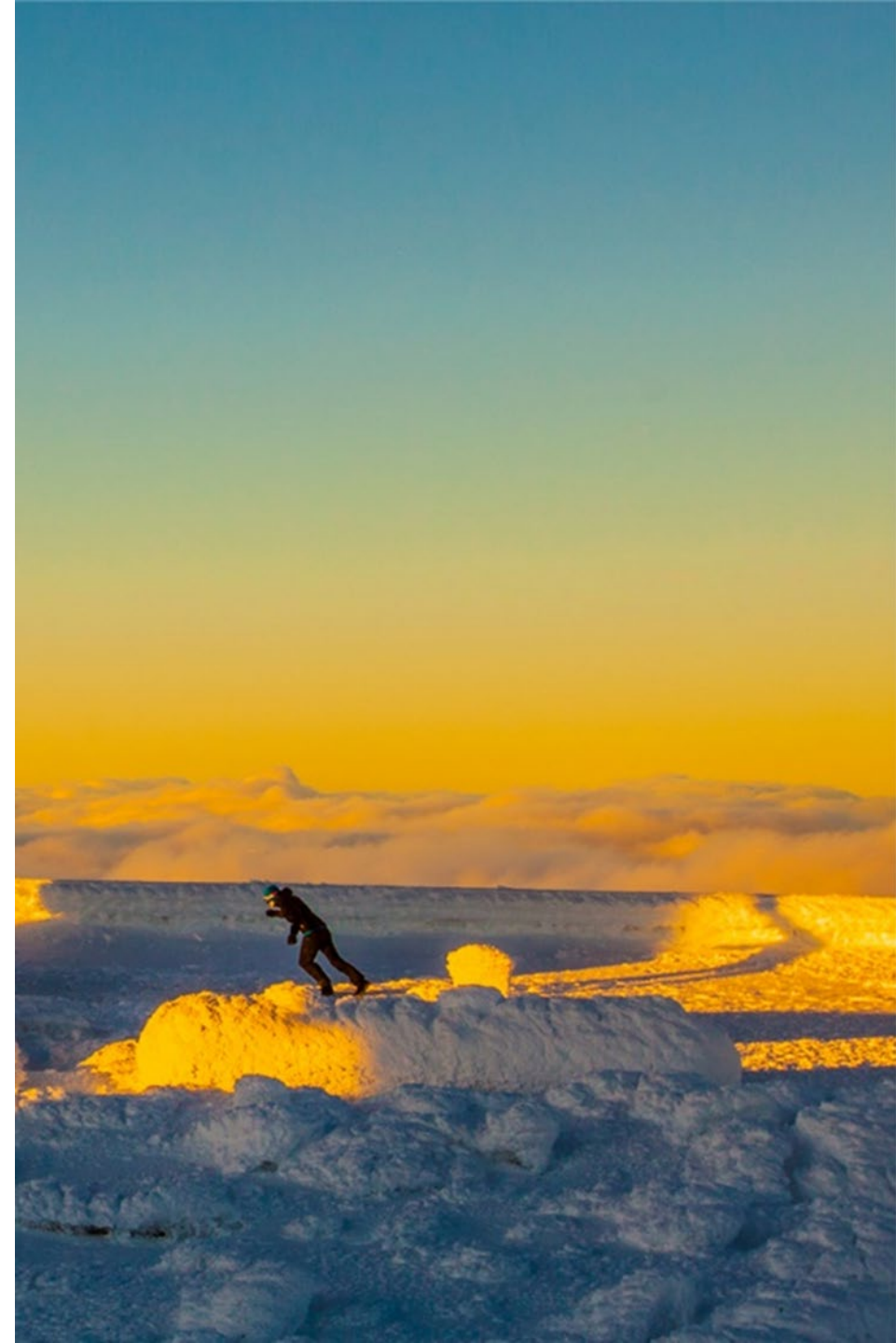
Using the B-16 present weather column, only analyzed hourly data when snow and snow showers were recorded

- Other solid precipitation was likely present such as sleet, ice pellets, or freezing rain and contributed to the amount of solid precipitation recorded during the synoptic observations

For B-15 data was filtered the SLR was only calculated if both solid accumulation and liquid equivalent were present in amounts > Trace (≥ 0.01 " for liquid *and* ≥ 0.1 " for solid)

(Initial) Research Goals

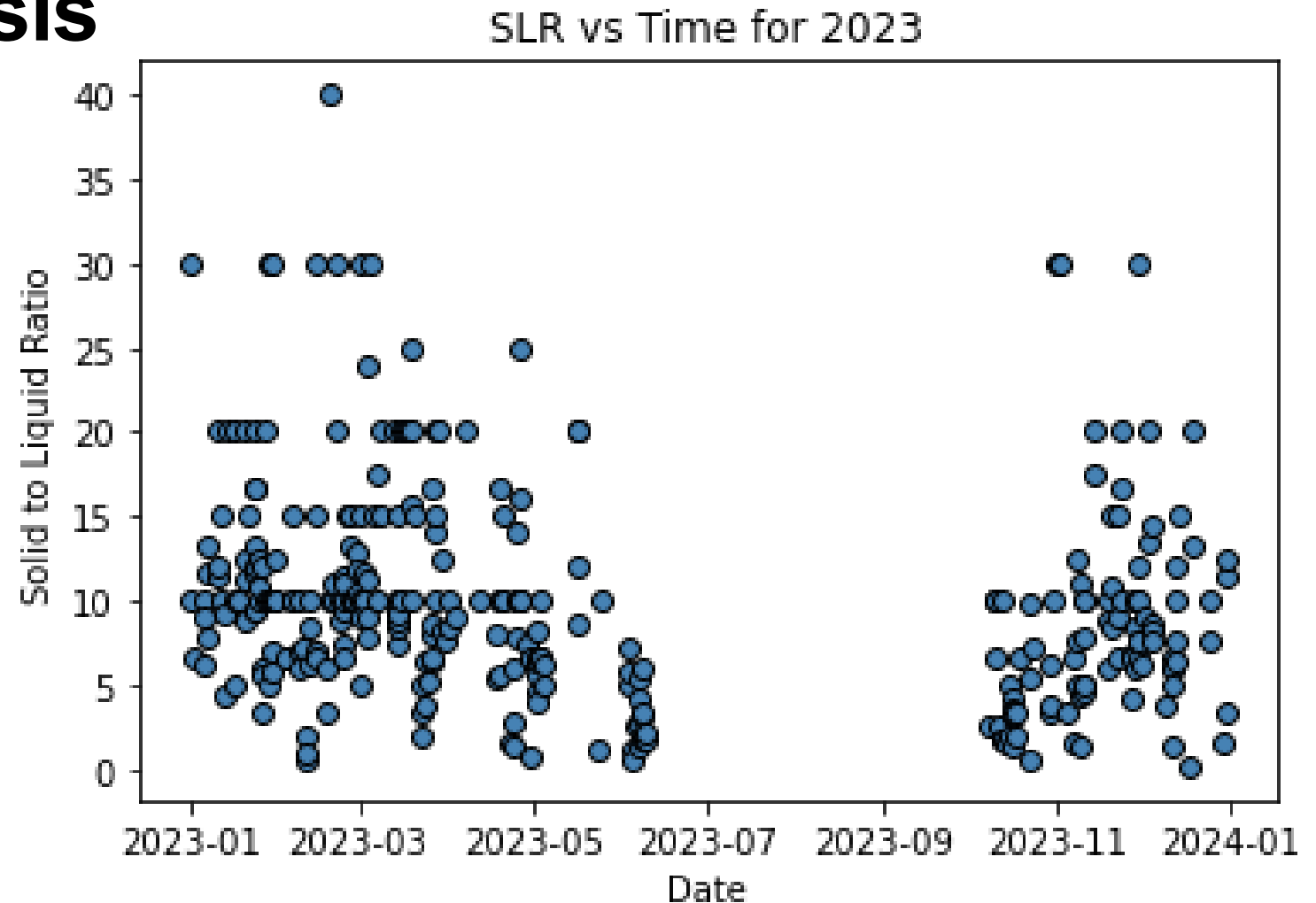
- What is the most common ratio for Mount Washington?
- Do temperatures influence SLR?
- Do wind speed or direction influence SLR?
- Is there a seasonality to SLR?
- Do synoptic patterns/airmass origin influence SLR?
- Have snowfall ratios changed over time?
- How does estimating snowfall impact this research?



6-Hourly SLR Analysis

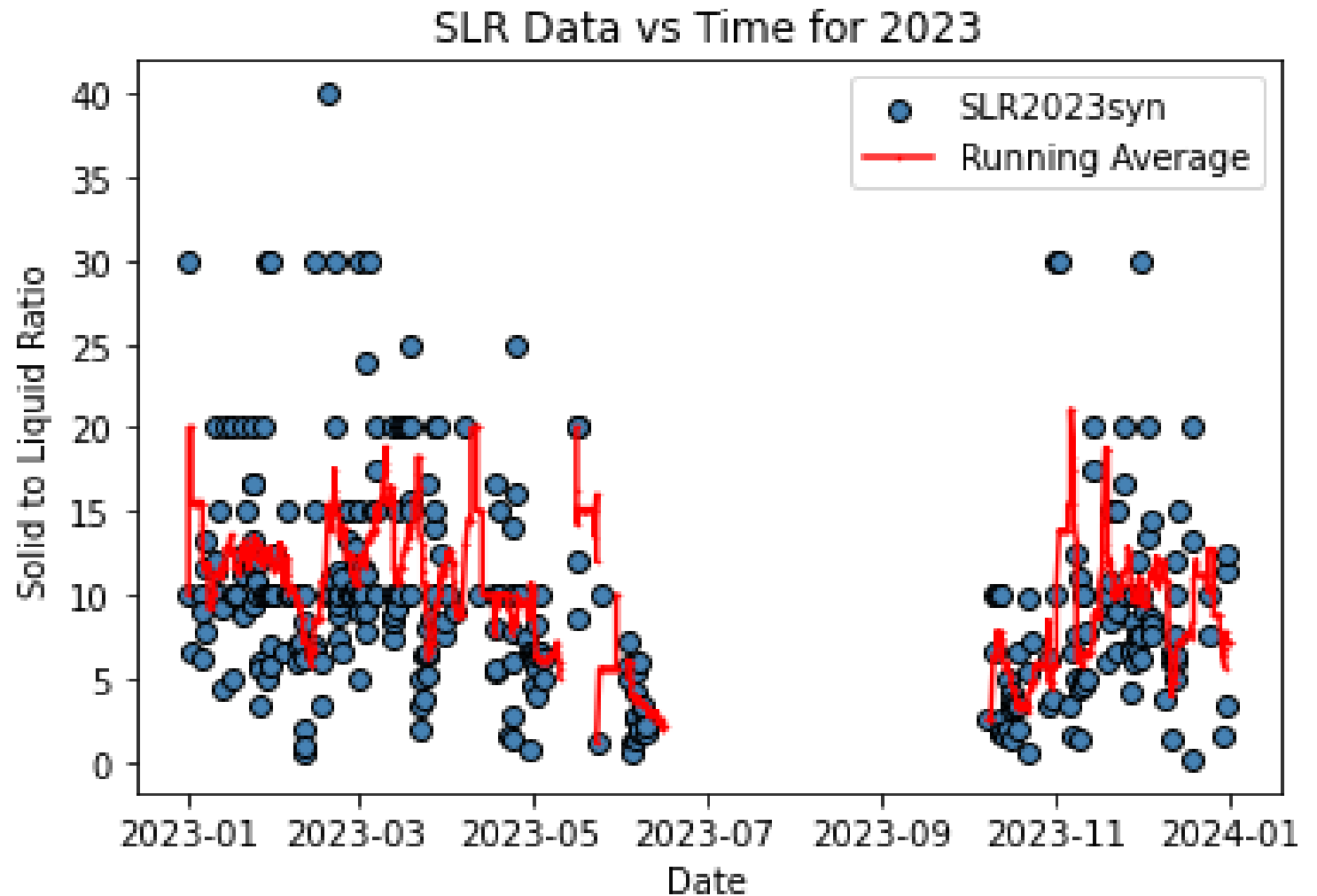
- Calculated SLR from 6-hourly synoptic observations
- Only calculated if both values (solid and liquid) are > Trace
- After this filtering, there are **317** synoptic observations (>79 days worth) that met this criteria

$$SLR = \frac{\text{Solid Accumulation}}{\text{Liquid Equivalent}}$$



Running Average

- Each data point for Running Average intakes 27 observations (approximately 7 days)
- Average SLR for 2023: **9.9:1**
 - Calculated by averaging all the synoptic observations that met the above criteria



Daily SLR Analysis

- Sum of 4 consecutive observations of both solid accumulation and liquid equivalent that met the above criteria
- If solid accumulation was zero, then replaced liquid equivalent with zero to exclude times when only liquid precipitation that fell
- Then divided to find SLR daily averages
- **216** days with snowfall in 2023

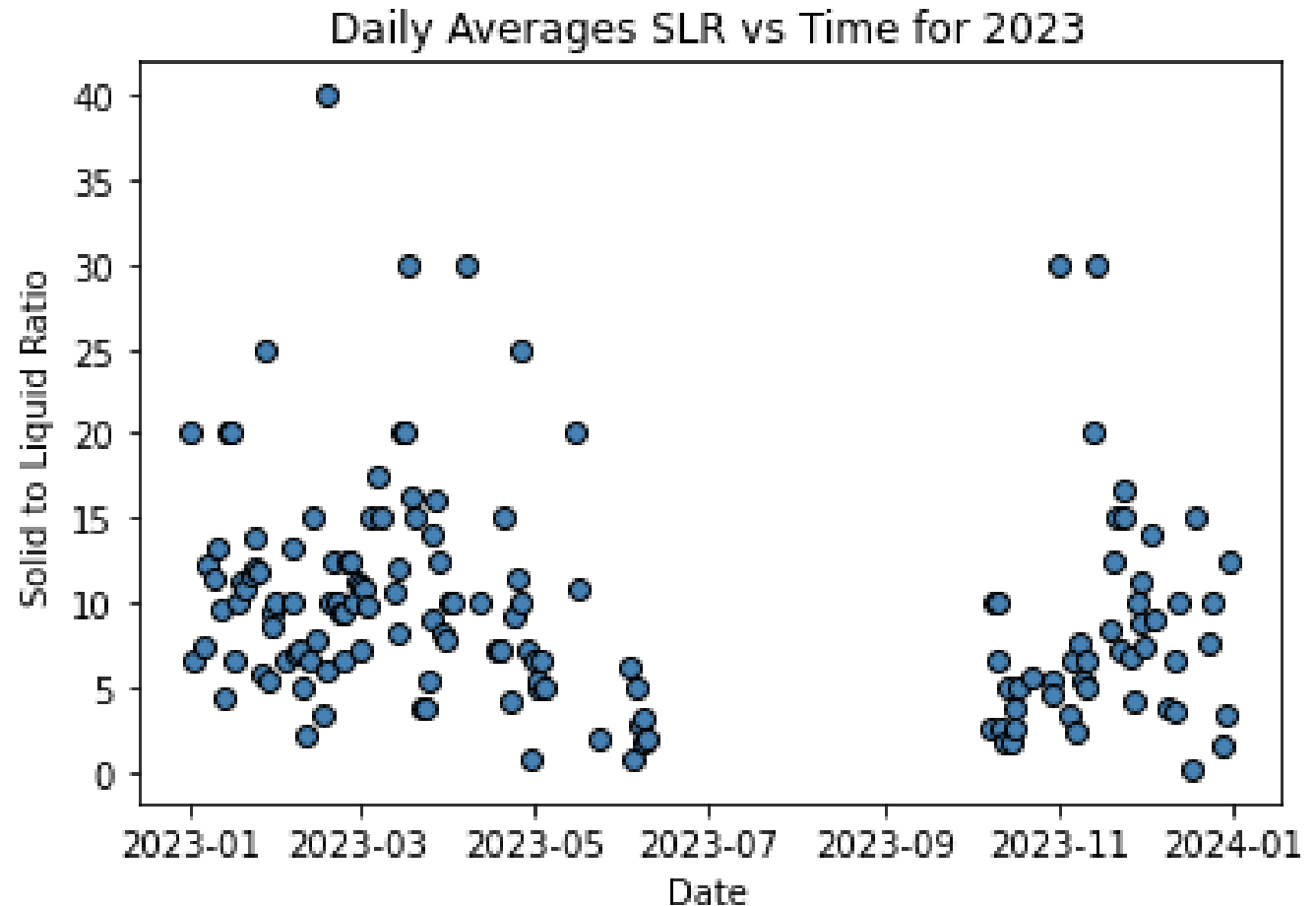
Daily SLR Average Observations

07:00 same day

13:00 same day

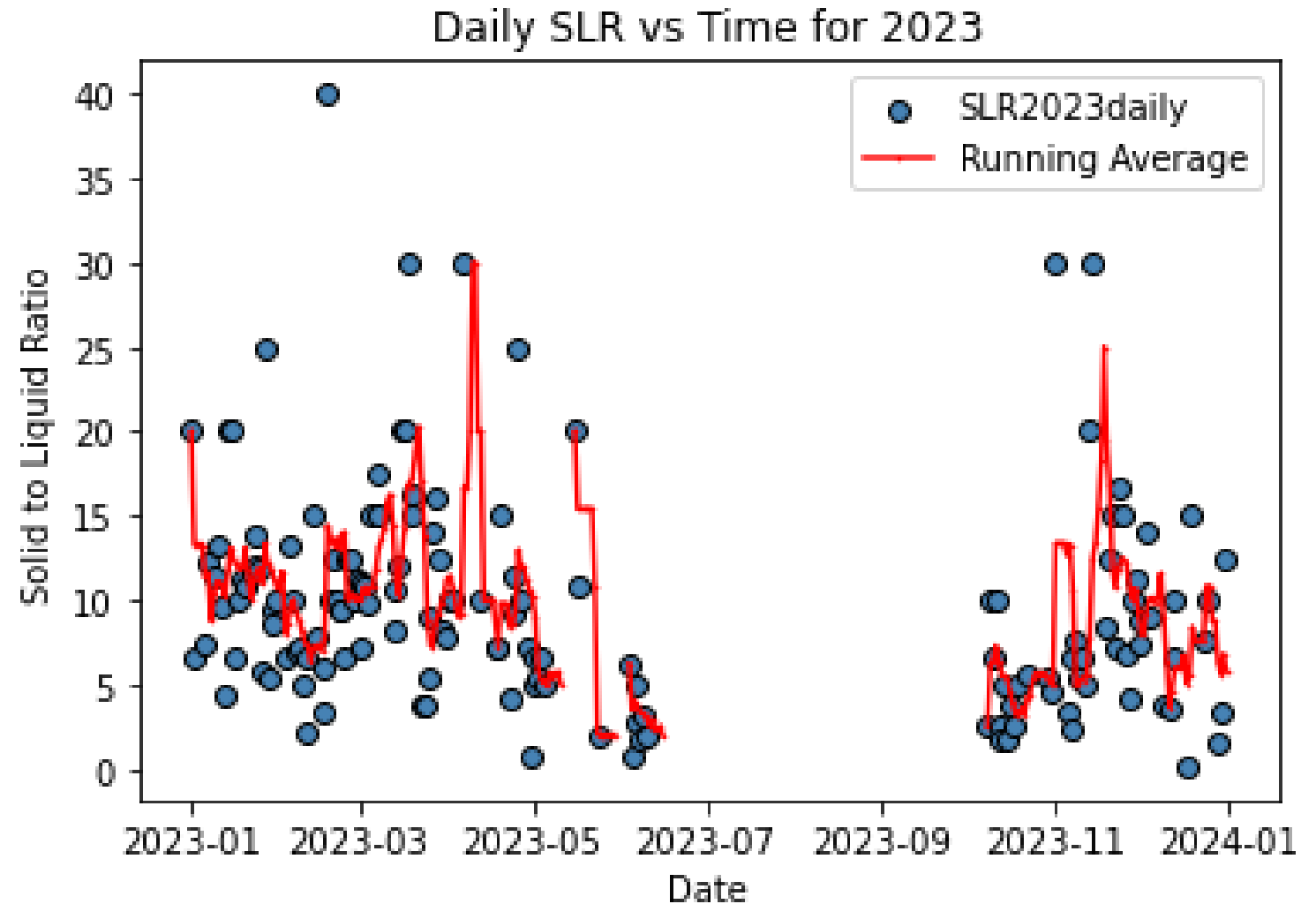
19:00 same day

01:00 next day

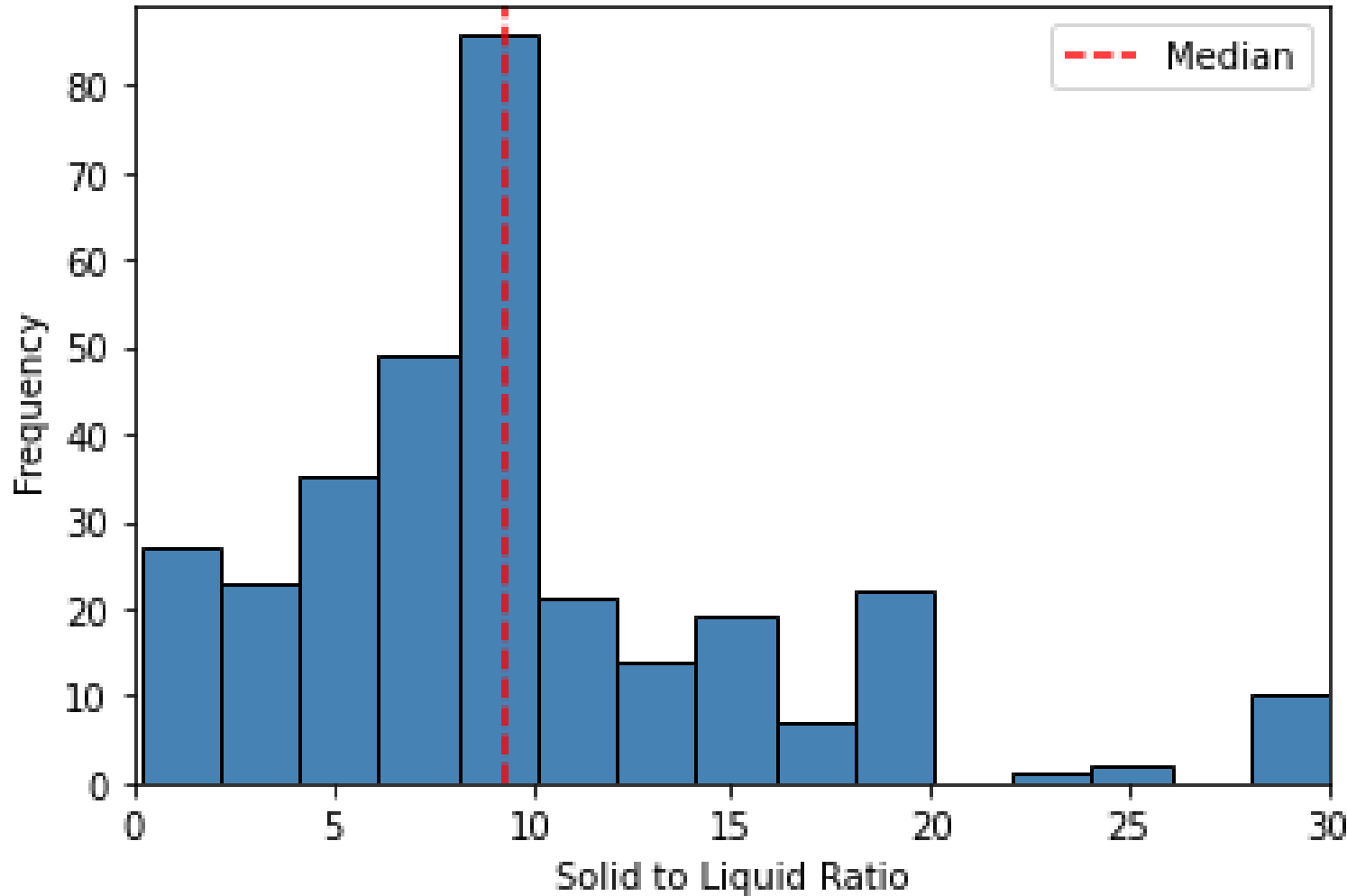


Running Average

- 7-day moving window which took in the pre-processed daily SLR values.
- There remains significant variability
- Daily Average SLR for 2023: **9.8:1**
 - Calculated by averaging the daily SLR values derived earlier



SLR Data for 2023



SLR Frequency (6-hourly)

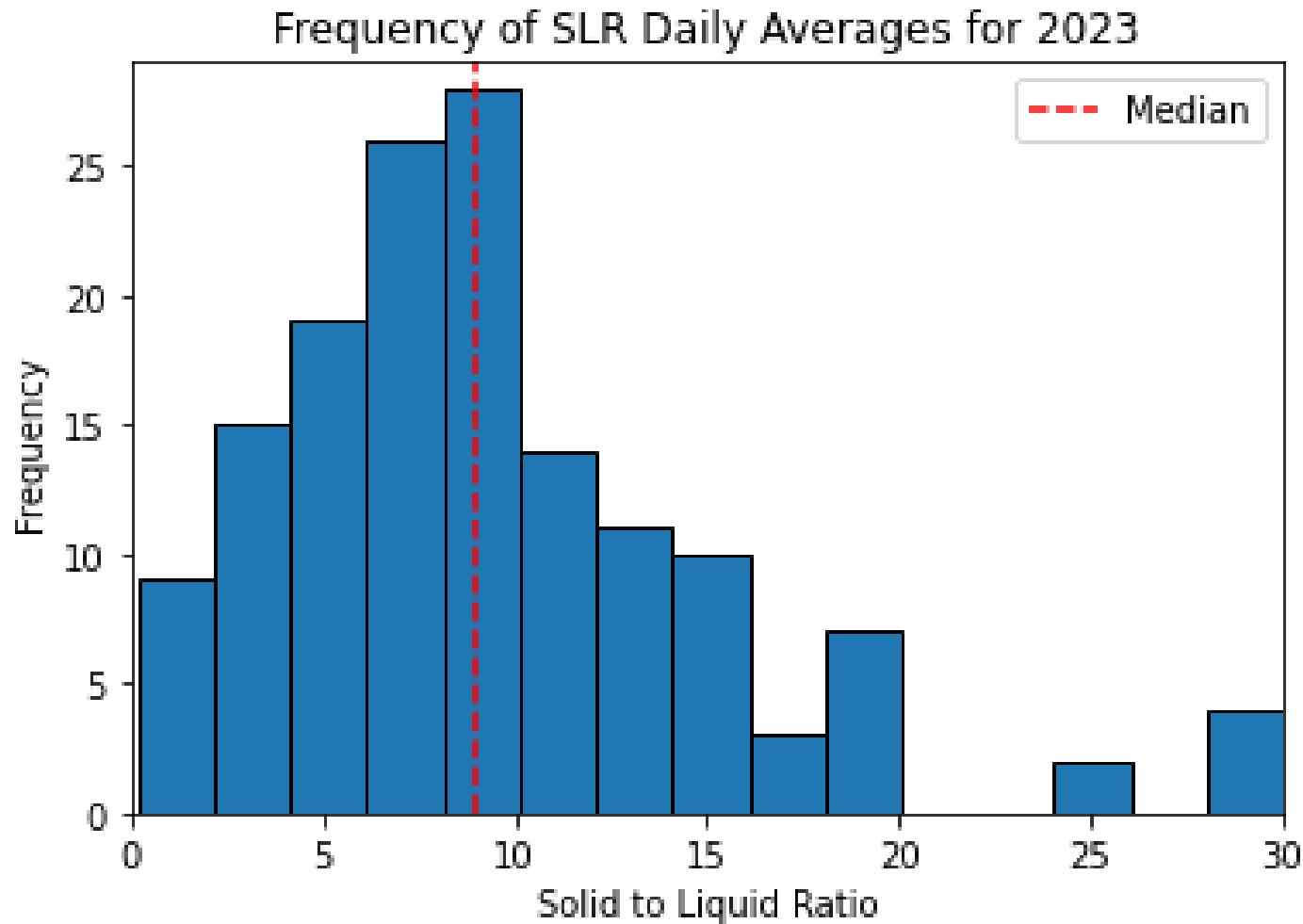
- 20 bins, plot range 0-30, with SLR stepping by 2 with 1 value >30
- X-axis condensed to increase readability
- High frequency of 0-2 potentially from mixed precipitation and or mainly rain events.

Most common SLR

8-10 frequency of 86 observations
6-8 frequency of 49 observations

- Median value of **9.3:1**

SLR Daily Frequency



- 20 bins, plot range 0-30, with SLR stepping by 2 with 1 value >30
- X-axis condensed to increase readability

Most common SLR

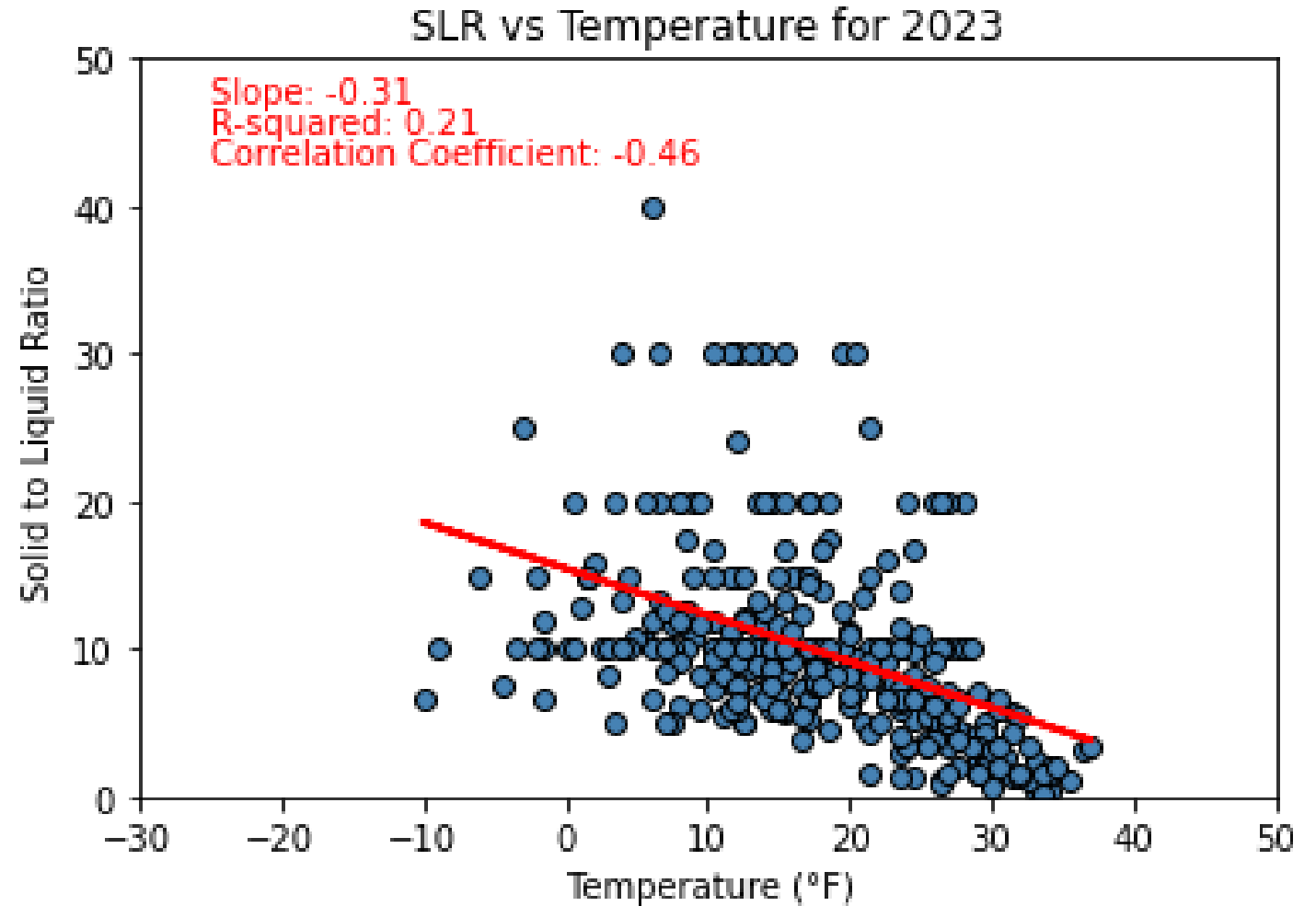
28 observations between 8 and 10

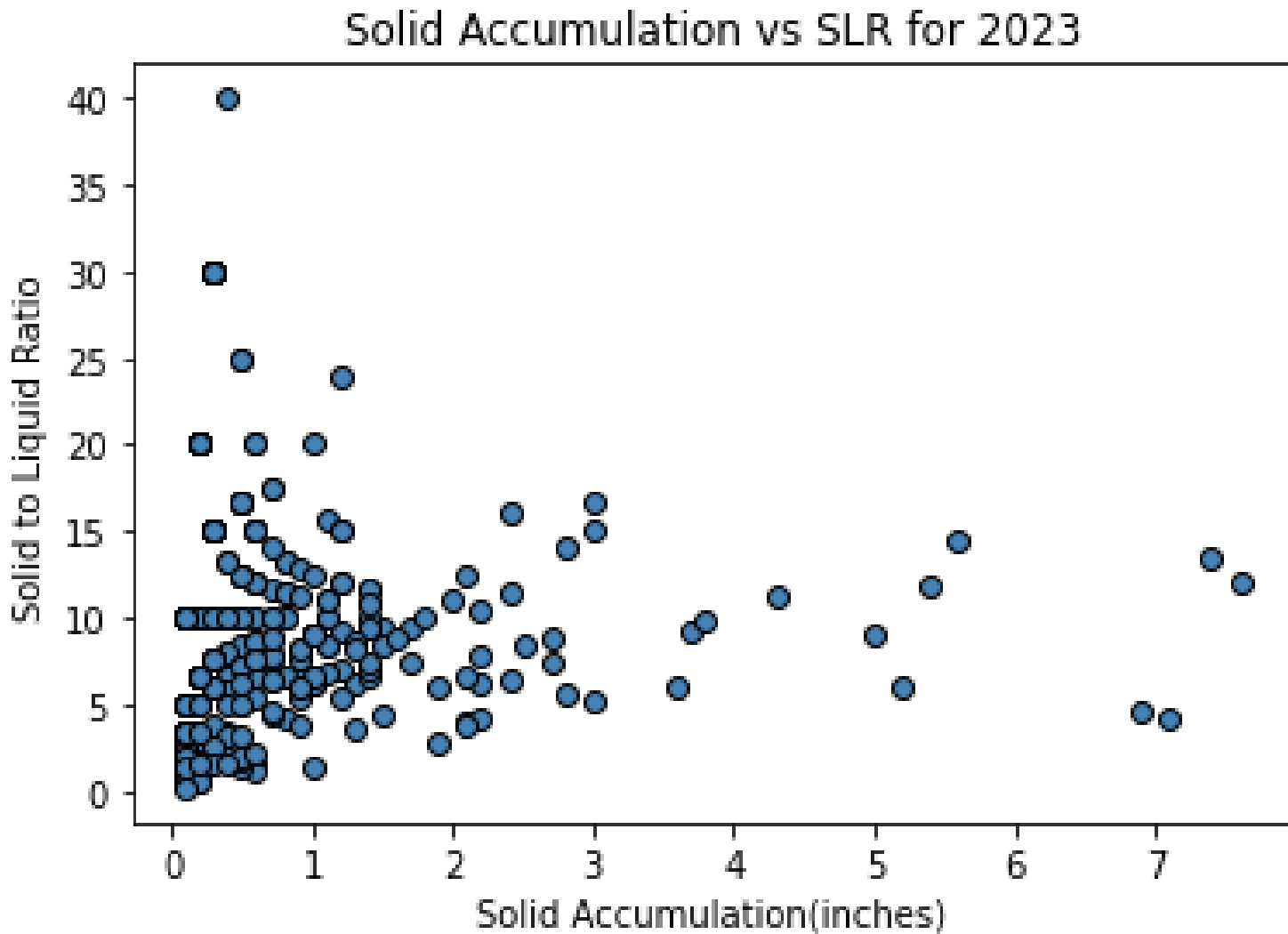
26 observations between 6 and 8

- Daily Median value of **9.0:1**

SLR vs Temperature Analysis

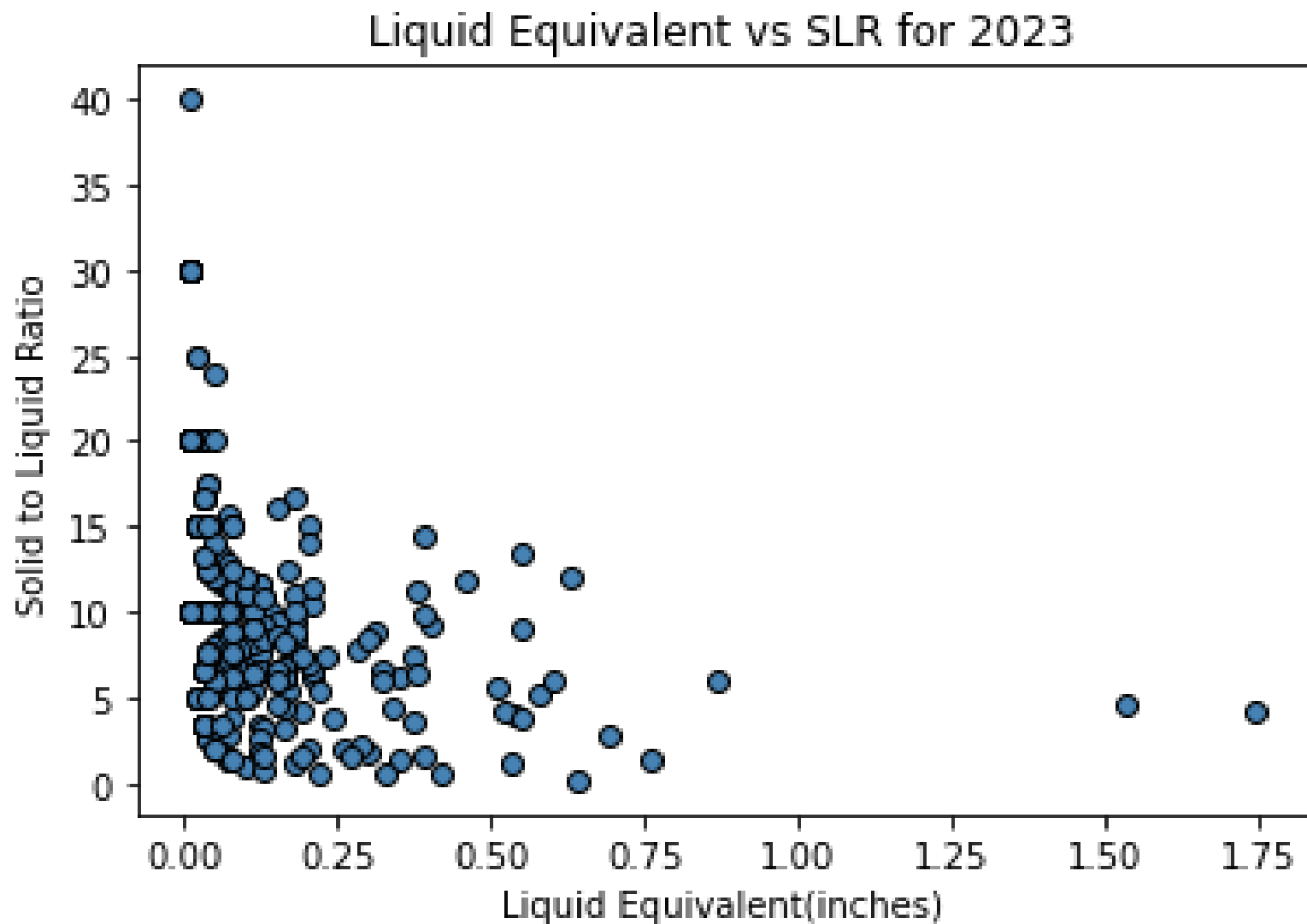
- Distinct lines at 10, 20, and 30 SLR at various temperatures
- Higher temperatures (25-35 degrees) generally have low SLR values
- From the B15, temperature plotted is calculated taking the average of the 6-hour max temp and min temp from each observation
- Correlation Coefficient between SLR and Temperature is moderately negative (-.46)
- R-squared value of 0.21 shows that a significant amount of variance remains unexplained
- Future work- trying a logistic curve to see if that's a better fit





Accumulations

- Most frequent snowfall accumulations are between 0.1 - 1 inch
- 6-hourly not daily SLR
- Large variability at lower accumulations, relatively less spread at higher accumulations)

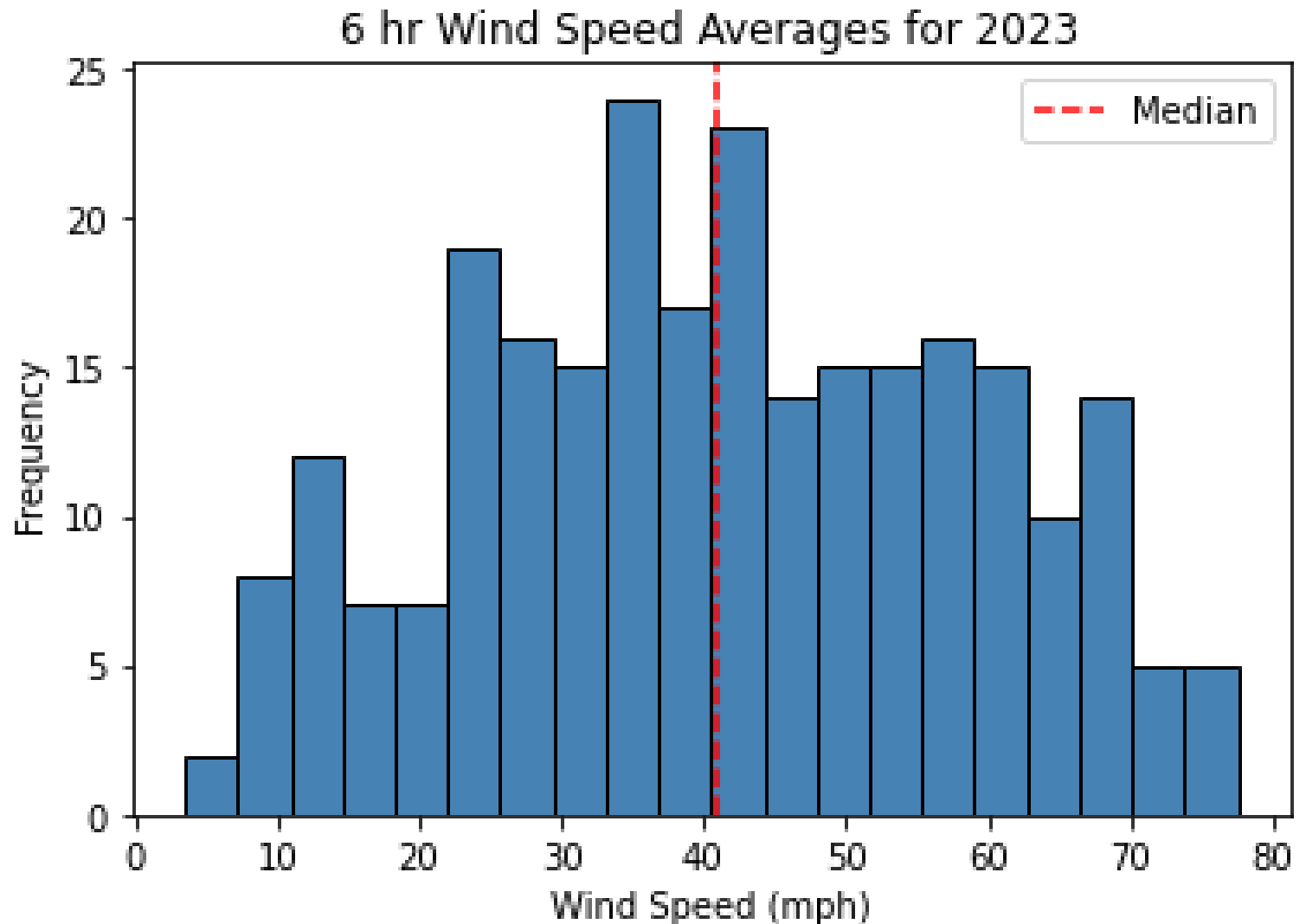


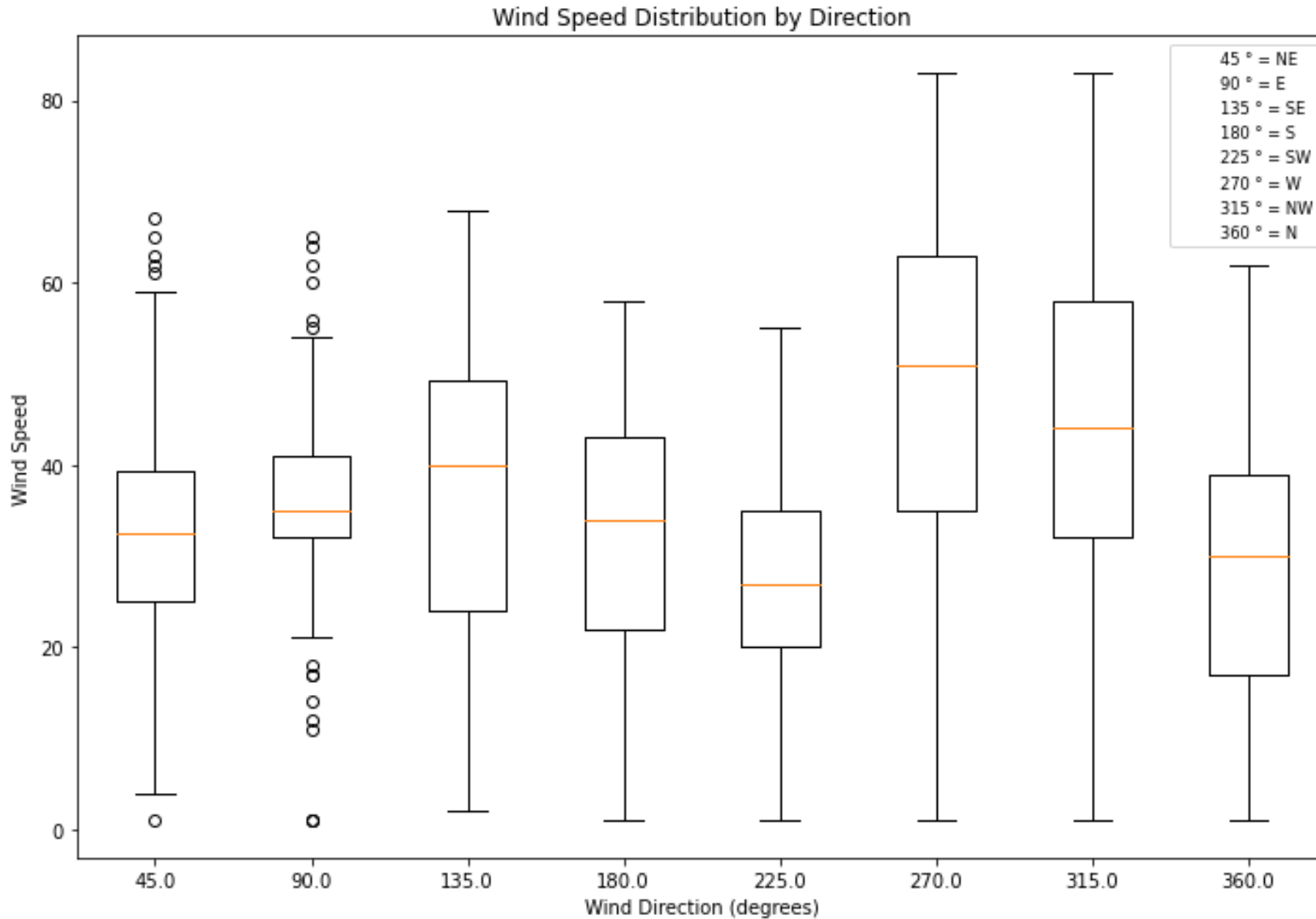
Liquid Equivalent

- Amount of liquid equivalent for each snowfall measurement
- Values are most common between 0.01- 0.25 inches
- Very light precipitation events have largest variation in SLR
- Frequent low SLR ratios may be due to mixed precipitation or precipitation type transitions (snow → rain or rain → snow) within the 6-hour time period

Wind Speed

- 6 hour average wind speeds are derived from B16
- Data filtered so winds displayed only during 6 hour observations when snow and snow showers were present
- Most frequent wind speeds during observations with snowfall ~35 mph and ~42 mph, though a relatively even spread of observations from ~25 mph to ~65 mph
- Median value: 41.0 mph



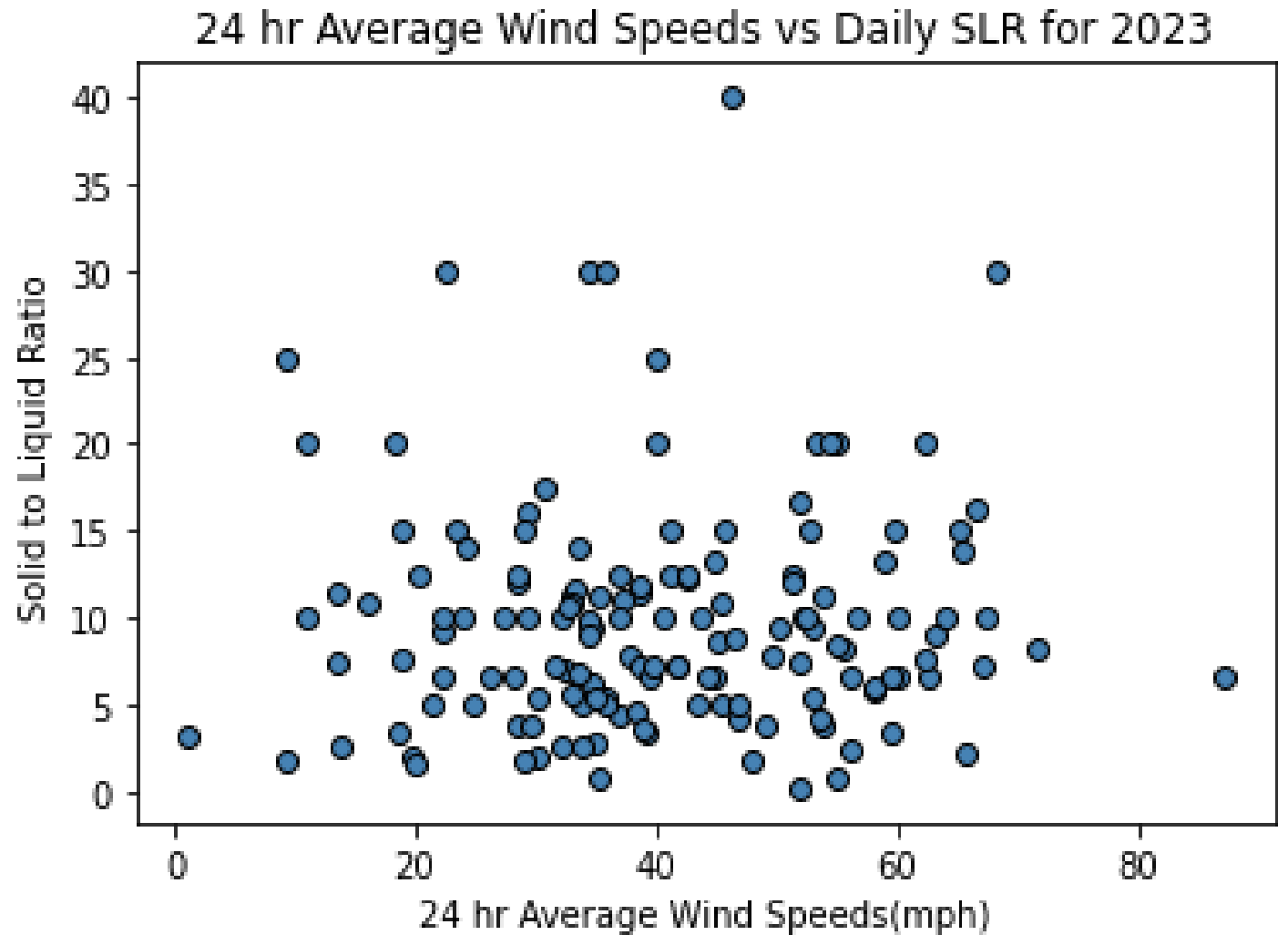


Wind Direction

- Wind Speed and Direction plotted is only at times when the present weather has snow and snow showers from the hourly data
- Orient ourselves with variation and frequency of winds

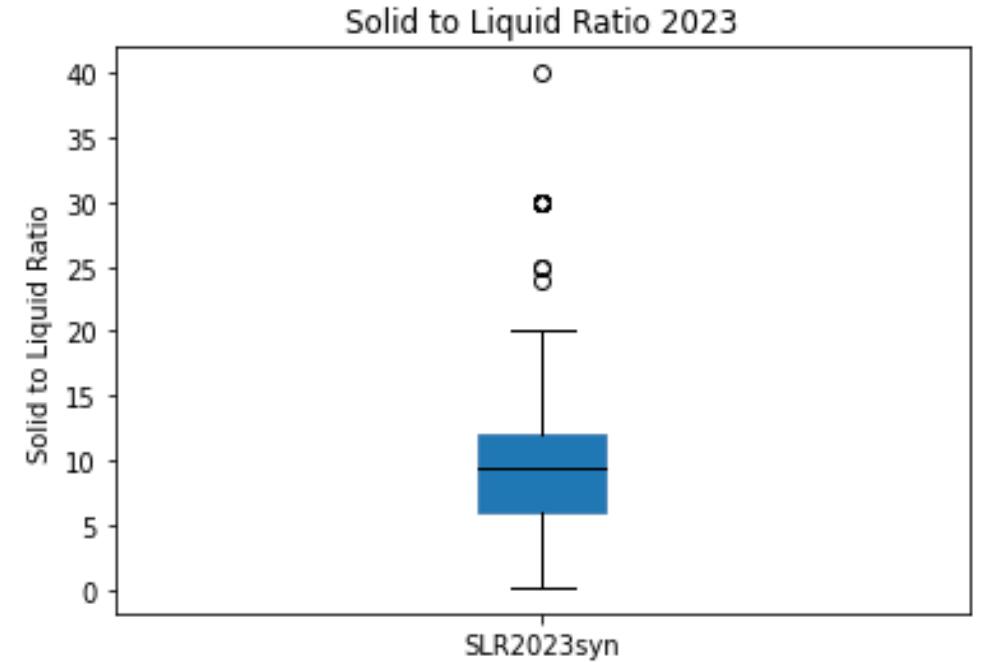
Wind Analysis

- 24 hour average wind speeds from B-16
- Little visual trend between wind speeds and SLR
- To expand in the future on this analysis
 - Only use wind speed values when snow and snow showers are present
 - Use 6 hour average wind speeds rather than 24 hours



Future Work

- Expand wind analysis
 - Connect wind direction to SLR
- Monthly SLR boxplot to highlight seasonality
- Overlay solid accumulation and liquid equivalent to SLR histogram
- Filter data with just snow present, no freezing precipitation or rain
- Calculate a 'snow temperature' using snow accumulations and the temperature it fell at
- Once happy with 2023 analysis/results, move to include past years!
 - Plot comparison box plots of SLR from multiple years
 - Histogram overlay of frequency over multiple years





Thank You!

5/20/2024

